A Research Note

ESTIMATION OF DIGESTIBILITY OF MEAT PRODUCTS CONTAINING EXTENDERS

ABSTRACT

Procedures involving pepsin and pepsin-trypsin digestion of frankfurters were evaluated in efforts to develop a term for "apparent" digestibility to extend applications of estimations of the protein efficiency ratio (PER) of meat food products by ERRC-APHIS equations. The estimations, termed Est-PER are based only on amino acid composition. Samples of raw emulsion, cooked frankfurters, and cooked and smoked frankfurters containing all meat, meat extended with soy products, and meat extended with nonfat dried milk were treated with pepsin or pepsin-trypsin. Their digestibility was determined as % nitrogenous substances and/or % protein digested. Nitrogen digestibility of cooked-smoked product was also determined by bioassay. Digestibility ranged around 90% with pepsin-trypsin treatment, whereas digestibility with pepsin treatment was half this and too low for measuring "apparent" digestibility. Pepsin-trypsin digestibility of cooked and of cooked and smoked frankfurters did not differ; raw frankfurters were significantly less digestible. Average % protein digestibility was somewhat lower than average % nitrogen digestibility on pepsin-trypsin digestion and more closely approached values for nitrogen digestibility determined by bioassay. Subject to confirmatory studies, the results indicate that % protein digestibility as measured by a procedure involving pepsin-trypsin digestion may be an acceptable additional term in estimating Est-PER.

INTRODUCTION

A RELATIVELY RAPID chemical-mathematical procedure for estimating the protein efficiency ratio (PER) of meat, poultry, grain and yeast products within ±0.2 PER of PER values obtained by the official method of the AOAC (1975) has been developed and used in practice (Alsmeyer et al., 1974; Happich et al., 1975a). Estimates of PER, herein indicated as Est-PER, are calculated by substituting data on amino acid composition into simple equations. Noting that the Est-PER values of proteins of meat food products containing bean, oilseed, and marine products are not acceptably accurate, we are engaged in improving the equations, one requisite being that we obtain additional data on the amino acid composition and PER values of products of interest and examine equations developed from the larger base of data. In addition, we are developing a chemically derived term for "apparent" digestibility which can be incorporated into equations. The potential usefulness of this term was suggested by our observation that correction for digestibility substantially improved Est-PER of products having apparent nitrogen digestibility below 90% (Happich et al., 1975b).

Methods employing digestion with pepsin or pepsin-trypsin have been used to estimate the in vivo digestibility of food proteins (Sheffner, 1967) and appear potentially applicable to our problem. Our initial effort in investigating this approach was to determine the digestibility of total nitrogenous substances and of proteins in raw, cooked, and cooked and smoked all meat and extended frankfurters to evaluate the application of the enzymic methods for the first time to typical meat food product.

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EXPERIMENTAL

Preparation of experimental sausage

Five lots of frankfurters were prepared in the pilot plant. An all meat lot was prepared using the formula: 5.35 kg lean beef, 3.12 kg lean pork, 3.91 kg pork fat, 1.9g sodium nitrite, 6.6g sodium ascorbate, 245g sugar, 310g sodium chloride, 65g spices and 3.4 kg ice. The emulsion was comminuted to 15.5°C in a Model KA110 Koch-Alpina silent cutter: the emulsion was stuffed and cooked, or cooked and smoked, to 71°C. The other lots were prepared similarly, except that they contained, in addition, 1.11 kg of textured vegetable protein (Pro-lean, Miles Laboratories, Inc.), toasted soy flour (Nutrisoy, Archer-Daniels Midland Co.), soy protein concentrate (Promosoy-100, Central Soya Chemurgy Division), or nonfat dried milk (Land O'Lakes, Inc.).

Preparation of samples

Major portions of the lots of raw, cooked and cooked and smoked frankfurters were skinned, ground through a 1/8-in. plate, freeze dried, and then partially defatted by pressing in a Model B Carver Press at 24,000 psig (cam diam, 90 mm) at 24°C for 2–4 hr to provide samples for tests of enzymic digestibility and for bioassays. Percent apparent nitrogen digestibility, (N intake minus fecal N/N intake × 100) was determined on cooked-smoked samples using a standard method for bioassay (NAS, 1963); except that five male weanling rats were used in the 28-day feeding tests. Total nitrogen determinations were determined by the macro-Kjeldahl procedure (AOAC, 1975). The protein contents of the resulting samples and the relative portions of meat and additive proteins are shown in Table 1.

Enzyme treatments

The freeze-dried, partially defatted samples prepared from the frankfurter lots were treated with pepsin, or with pepsin followed by trypsin as has been previously described (Sheffner et al., 1956), or carried through the steps of the procedure (Fig. 1) but without enzymes.

The macro-Kjeldahl N content of the samples and the digested and

Table 1—Changes in bacterial populations in egg products incubated at 12°C

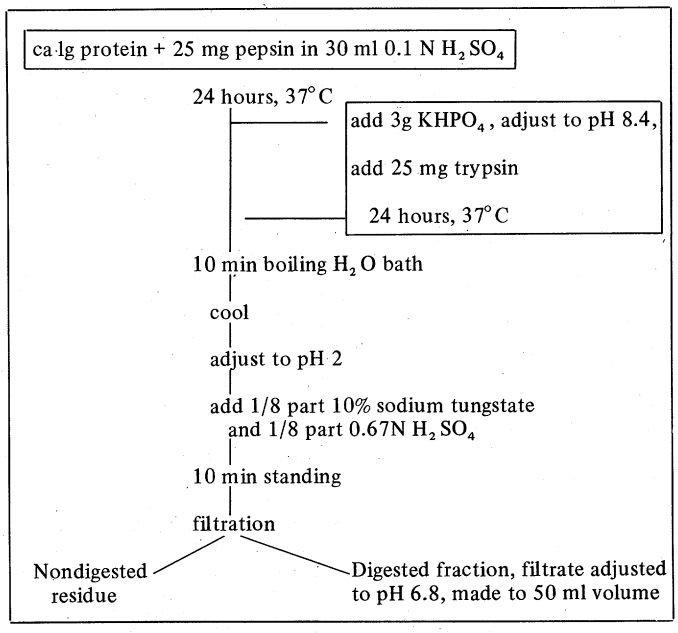

Fig. 1—Procedure for enzyme treatment.

undigested fractions were determined. The percent digestibility of total nitrogenous compounds (NC) was calculated as:

$$\frac{D\,\%}{NC} = \frac{N\ digested}{N\ total} \times 100, \text{ or}$$

$$\frac{N\ total - N\ nondigested}{N\ total} \times 100$$

In applying the procedure without enzymes, the fractions after filtration were designated dissolved and nondissolved rather than digested and nondigested, respectively. The N content was determined for these fractions also. The digestibility of protein (P) was calculated as

$$\frac{D\,\%}{P} = \frac{N\ digested - N\ dissolved}{N\ total - N\ dissolved} \times 100, \text{ or}$$

$$\frac{(N\ total - N\ nondigested) - (N\ total - N\ nondissolved)}{N\ total - (N\ total - N\ nondissolved)} \times 100$$

RESULTS & DISCUSSION

AS SHOWN IN Table 1 the soy products and nonfat dried milk contributed from approximately 20–30% of the total protein content (N X 6.25) of the frankfurters in which they were ingredients. Digestibility, determined as percentages of total nigtrogenous components and of protein digested of raw, cooked and cooked-smoked frankfurters, is shown in Table 2; the digestibility of the cooked-smoked samples obtained by bioassay is also shown. The bioassay indicated that the digestibility of the cooked-smoked samples ranged from 88–90%. These were approached only by values for digestibility obtained after pepsin-trypsin digestion. Of these, the values for protein digestibility (bracketed) were closer than those for nitrogen digestibility (unbracketed), which probably indicates nothing fundamental, but only that one empirical approach agreed better than the other in estimating biodigestibility. An improvement in digestibility occurred on cooking or cooking and smoking. Digestibility based on nitrogenous compounds or on proteins was significantly greater for pepsin-trypsin than for pepsin alone (P = 0.01), as previously reported by Sheffner et al., 1956. Also the digestibility of cooked samples was significantly greater than that of raw samples (P = 0.01). Analysis by least significant difference showed that the digestibility values for cooked and cooked and smoked frankfurters were not different. An analysis of variance was performed. The relative effects of enzymes, additives and processing were indicated by F-values of 3835, 2.40 and 19.9, based on digestibility of nitrogenous components, and 13,197, 9.69, and 41.32, based on the digestibility of proteins, respectively; the effect of an interaction of enzymes and processing was indicated by F-values of 5.03 and 16.6, respectively. All F-values except F = 2.40 were significant (P = 0.01). The pronounced effects of enzymes were as expected. It is especially noteworthy that the influence of processing was more marked than the influence of the additives studied, suggesting a need for study of the effects of processing in extending the work. The results with pepsin-trypsin appear to warrant further investigation of this procedure for estimating protein digestibility to be used as a factor in computing Est-PER. Further studies are needed to obtain data on amino acid and peptide composition of the digests and to correlate the bioassay and enzyme digestibility, particularly on products of lower digestibility.

Table 1—Content and source of protein in frankfurter protein preparations

Frankfurter preparation	Protein content of samples (%)	Protein source	
		Meat (%)	Additive (%)
All meat	42.6	100	0
Meat + textured vegetable protein	42.0	69.6	30.4
Meat + toasted soy flour	44.3	74.6	25.4
Meat + soy protein concentrate	41.0	69.3	30.7
Meat + nonfat dried milk	38.1	80.5	19.5

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Reference to a brand or firm name does not constitute endorsement by the U. S. Department of Agriculture over others of a similar nature not mentioned.

Table 2—Percent digestibility of nitrogenous components and proteins[a,b]

Samples	Raw emulsions		Frankfurters				
			Cooked		Cooked and smoked		
	Pepsin	Pepsin and Trypsin	Pepsin	Pepsin and Trypsin	Pepsin	Pepsin and Trypsin	Bioassay[c]
All meat	42.2 (36.8)	87.6 (80.3)	50.8 (40.5)	93.2 (88.2)	48.6 (37.1)	92.7 (89.1)	90
Textured vegetable Protein	39.6 (38.5)	88.9 (81.2)	46.9 (39.2)	90.1 (87.2)	45.9 (39.6)	90.8 (88.2)	89
Toasted soy flour	41.9 (39.4)	86.3 (78.2)	50.2 (39.8)	88.5 (84.2)	50.1 (38.4)	87.6 (86.3)	89
Soy protein Concentrate	42.0 (38.1)	88.7 (81.5)	48.3 (39.3)	89.5 (87.6)	48.1 (39.5)	89.2 (88.4)	88
Nonfat dried milk	44.8 (40.1)	89.1 (83.4)	51.6 (42.7)	91.2 (89.3)	49.9 (43.5)	91.7 (87.9)	88

[a]Percent digestibility of nitrogenous components are unbracketed and of proteins bracketed.

[b] Digestibilities, % are averages of duplicate determinations.

[c]Apparent nitrogen digestibility, % = $\frac{(N\ intake\ minus\ fecal\ N)}{N\ intake} \times 100$.